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CLAIMS AMENDMENTS

Please amend claims 1, 3-5, 7-10, 12-19, 21-32, 34-40, 42, 44-45, 47-48, 51, 53-65, 67-70, 72-79, 81-92, 94-100, 102, 104-109, 111, 113-121. Please add new claims 122-200 All other claims remain unchanged.

1 1.   (currently amended) A system for identifying ~~detecting~~ and
2 measuring concentrations of elements in fluids, comprising:
3   an ionic preconcentration cell, comprising:
4   an upper high surface area electrode comprising a high
5   specific surface area thereof;
6   a lower high surface area electrode comprising a high
7   specific surface area thereof, substantially parallel to
8   said upper high surface area electrode;
9   a central flow interelectrode gap separating said upper
10   and lower high surface area electrodes by a predetermined
11   interelectrode gap width; and
12   fluid flow means for flowing a fluid through said
13   central flow interelectrode gap; and
14   ~~————~~calibration data associated with said cell
15 characterizing a response from said cell when said cell or an
16 equivalent cell is exposed to x-rays under calibration
17 conditions, used in combination with test data characterizing a
18 response from said cell when said cell is exposed to x-rays under
19 test conditions, to deduce ~~enabling~~ an identity, or measurement
20 of concentration, of at least one element in said fluid ~~to be~~
21 ~~deduced~~.

1 2.   (original) The system of claim 1, further comprising:

6

2   voltage application means for applying a voltage

3   differential between said upper high surface area electrode and

4   said lower high surface area electrode while said fluid is

5   flowing through said central flow interelectrode gap.

1   3.   (currently amended) The system of claim 2, said voltage

2   application means further comprising:

3   a transportable voltage supply connected across said upper

4   and lower high surface area electrodes for applying an

5   electrostatic charge across said electrodes and thereby

6   maintaining ions from said at least one element entrained in said

7   electrodes during transport of said ionic preconcentration cell-

8   supplying said voltage differential.

1   4.   (currently amended) The system of claim 1, said ionic

2   preconcentration cell further comprising:

3   an upper x-ray transmission window in intimate contact with

4   an upper surface of said upper high surface area electrode.

1   5.   (currently amended) The system of claim 4, said ionic

2   preconcentration cell further comprising:

3   a lower x-ray transmission window in intimate contact with a

4   lower surface of said lower high surface area electrode.

1   6.   (original) The system of claim 1, said ionic

2   preconcentration cell further comprising:

3   inlet flow means for entering a fluid into said ionic

4   preconcentration cell and enabling said fluid to flow through

5   said central flow interelectrode gap.

7

1   7.   (currently amended) The system of claim 6, said inlet flow

2   means comprising at least one inlet flow slot substantially

3   coplanar with said central flow interelectrode gap.

1   8.   (currently amended) The system of claim 6, said inlet flow

2   means comprising a plurality of inlet flow tubes substantially

3   coplanar with said central flow interelectrode gap and

4   substantially parallel with one another.

1   9.   (currently amended) The system of claim 6, said inlet flow

2   means comprising turbulence enhancement means for enhancing a

3   turbulence of the flow of said fluid to induce mixing of said

4   flow to enable uniform extraction of said at least one element

5   from the flow stream.

1   10.   (currently amended) The system of claim 6, said inlet

2   flow means comprising access ~~debris cleaning~~ means for accessing

3   said inlet flow means for cleaning debris therefrom ~~said inlet~~

4   ~~flow means~~.

1   11.   (original) The system of claim 1, said ionic

2   preconcentration cell further comprising:

3   outlet flow means for exiting said fluid out from said ionic

4   preconcentration cell after said fluid has flowed through said

5   central flow interelectrode gap.

1   12.   (currently amended) The system of claim 11, said outlet

2   flow means comprising at least one outlet flow slot substantially

3   coplanar with said central flow interelectrode gap.

1   13.   (currently amended) The system of claim 11, said outlet

2   flow means comprising a plurality of outlet flow tubes

8

3 | substantially coplanar with said central flow interelectrode gap
4 | and substantially parallel with one another.

1 | 14.   (currently amended) The system of claim 11, said outlet
2 | flow means comprising access ~~debris cleaning~~ means for accessing
3 | said inlet flow means for cleaning debris therefrom ~~said outlet~~
4 | ~~flow means~~.

1 | 15.   (currently amended) The system of claim 4 ~~1~~, said ionic
2 | preconcentration cell further comprising:
3 | a cell collector body maintaining a position of said upper
4 | and lower high surface area electrodes and said upper x-ray
5 | transmission window relative to one another, said cell collector
6 | body in turn comprising a material comprising:
7 | substantially no conductivity;
8 | resistance to ionic leaching; and
9 | resistance to radiation degradation from x-rays to
10 | which said preconcentration cell is to be exposed.

1 | 16.   (currently amended) The system of claim 4 ~~1~~, said ionic
2 | preconcentration cell further comprising:
3 | a cell collector body maintaining a position of said upper
4 | and lower high surface area electrodes and said upper x-ray
5 | transmission window relative to one another, said cell collector
6 | body comprising a material selected from a ~~the~~ material group
7 | consisting of: plastic, glass, and fiberglass.

1 | 17.   (currently amended) The system of claim 4 ~~1~~, said ionic
2 | preconcentration cell further comprising:
3 | a cell collector body maintaining a position of said upper
4 | and lower high surface area electrodes and said upper x-ray

9

5 | transmission window relative to one another, said cell collector

6 | body comprising a non-conducting, machinable polymer

7 | substantially resistant to radiation degradation~~Delrin® plastic~~.

1 | 18. (currently amended) The system of claim 1:

2 | said upper high surface area electrode further comprising an

3 | upper electrode thickness less than or equal to approximately ℓ =

4 | 1/$(\mu*\rho)$, wherein:

5 | ℓ designates ~~is~~ an optical depth of said upper high surface

6 | area electrode when wetted with ~~in said fluid of a characteristic~~

7 | ~~photonic energy from~~ an element of interest for which a fluidic

8 | concentration is to be measured ~~by said system~~, in said fluid;

9 | μ designates ~~is~~ a mass absorption coefficient of said upper

10 | high surface area electrode when wetted with said element of

11 | interest in said fluid; and

12 | ρ designates ~~is~~ a material density of said upper high

13 | surface area electrode when wetted with said element of interest

14 | in said fluid.

1 | 19. (currently amended) The system of claim 18:

2 | said lower high surface area electrode further comprising an

3 | upper electrode thickness less than or equal to approximately ℓ =

4 | 1/$(\mu*\rho)$, wherein:

5 | ℓ designates ~~is~~ an optical depth of said lower high surface

6 | area electrode when wetted with ~~in said fluid of a characteristic~~

7 | ~~photonic energy from~~ an element of interest for which a fluidic

8 | concentration is to be measured ~~by said system~~, in said fluid;

9 | μ designates ~~is~~ a mass absorption coefficient of said lower

10

10 | high surface area electrode when wetted with said element of

11 | interest in said fluid; and

12 | ρ designates is a material density of said lower high

13 | surface area electrode when wetted with said element of interest

14 | in said fluid.

1 | 20.   (original) The system of claim 1, said upper high surface

2 | area electrode and said lower high surface area electrode further

3 | comprising an ordinary surface area approximately equal to an

4 | interrogation spot area of x-rays to which said preconcentration

5 | cell is to be exposed.

1 | 21.   (currently amended) The system of claim 4, said upper x-

2 | ray transmission window comprising a surface area approximately

3 | equal to an interrogation spot area of x-rays to which said

4 | preconcentration cell is to be exposed.

1 | 22.   (currently amended) The system of claim 2, said central

2 | flow interelectrode gap comprising said predetermined

3 | interelectrode gap width, designated d, within an interelectrode

4 | gap range specified by:

5

$$d = \frac{\sigma}{q\varepsilon} \frac{\Phi}{w_f} \frac{w_i}{n_f} \frac{A}{CF} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q\varepsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\varepsilon F},$$ wherein:

6 | ε designates a predetermined percentage of at least one

7 | element of interest to be extracted from said fluid, σ designates

8 | a composite conductivity of said fluid, Φ designates a potential

9 | applied by said voltage application means across said electrodes,

10 | $q = 1.60 \times 10^{-19}$ Coulomb designates the unit charge, A designates an

11 | ordinary surface area covered by said electrodes, n_f designates a

12 | number density of said fluid, w_i and w_f designate atomic /

11

13 molecular weights, respectively, of <u>said</u> at least one element of

14 interest and of said fluid, C designates a concentration of said

15 at least one element of interest in said fluid, and F designates

16 a flow rate of said fluid through said ionic preconcentration

17 cell;

18   said high surface area electrodes further comprise said

19 ordinary surface area A approximately equal to an interrogation

20 spot area of x-rays to which said preconcentration cell is to be

21 exposed;

22   said ε is chosen to be below approximately 5% for said at

23 least one element of interest;

24   said Φ is chosen to be below an electrochemical potential of

25 said at least one element of interest and below an electrolysis

26 potential of said fluid;

27   said F is chosen to exert no more than approximately .1 atm

28 of pressure upon an upper <u>x-ray</u> transmission window of said ionic

29 preconcentration cell in intimate contact with an upper surface

30 of said upper high surface area electrode;

31   said n_f and said w_f are chosen with reference to said at

32 least one element of interest; and

33   said w_i is chosen with reference to said fluid.

1   23.   (currently amended) The system of claim 22 ~~1~~, said

2   central flow interelectrode gap comprising said predetermined

3   interelectrode gap width, ~~designated~~ d, with:

4   a minimum gap width selected from a ~~the~~ minimum gap width

5   group consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

6   a maximum gap width selected from a ~~the~~ maximum gap width

12

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7 | group consisting of 2 mm, 5 mm, and 10 mm.

1 | 24.   (currently amended)   The system of claim 4, said upper x-

2 | ray transmission window comprising:

3 | an atomic number below 10;

4 | structural rigidity to support up to 1/10 atm. of pressure

5 | without bowing more than approximately 100 microns;

6 | substantial impermeability relative to said fluid;

7 | x-ray transparency greater than 90% for characteristic

8 | photon energies from an element of interest for which a fluidic

9 | concentration is to be measured by said system;

10 | x-ray scattering therefrom minimized to less than

11 | approximately 10% of radiation scattered from a column of said

12 | fluid equal to one optical depth in said fluid of a

13 | characteristic photonic energy from an element of interest for

14 | which a fluidic concentration is to be measured by said system;

15 | and

16 | freedom from any single contaminant in excess of 1 part per

17 | million, when measured by x-ray fluorescence.

1 | 25.   (currently amended)   The system of claim 5, said lower x-

2 | ray transmission window comprising:

3 | an atomic number below 10;

4 | structural rigidity to support up to 1/10 atm. of pressure

5 | without bowing more than approximately 100 microns;

6 | substantial impermeability relative to said fluid;

7 | x-ray transparency greater than 90% for characteristic

8 | photon energies from an element of interest for which a fluidic

9 | concentration is to be measured by said system;

13

10   x-ray scattering therefrom minimized to less than

11   approximately 10% of radiation scattered from a column of said

12   fluid equal to one optical depth in said fluid of a

13   characteristic photonic energy from an element of interest for

14   which a fluidic concentration is to be measured ~~by said system~~;

15   and

16   freedom from any single contaminant in excess of 1 part per

17   million, when measured by x-ray fluorescence.

1   26.   (currently amended) The system of claim 4, said upper x-

2   ray transmission window comprising a polyimid film comprising

3   structural rigidity to support up to 1/10 atm. of pressure

4   without bowing more than approximately 100 microns~~Kapton®~~.

1   27.   (currently amended) The system of claim 5, said lower x-

2   ray transmission window comprising a polyimid film comprising

3   structural rigidity to support up to 1/10 atm. of pressure

4   without bowing more than approximately 100 microns~~Kapton®~~.

1   28.   (currently amended) The system of claim 1:

2   said upper high surface area electrode and said lower high

3   surface area electrode each comprising a high surface area

4   material in turn comprising:

5   a large plurality of pores characterized by a specific

6   surface area of at least approximately 100 m^{23}/g;

7   an average pore diameter of said pores between approximately

8   30 nm and 10 nm per pore;

9   a distribution of the ~~said~~ pore diameters grouped with a

10   standard deviation of less than approximately 10nm around said

11   average pore diameter;

14

12   an x-ray transparency greater than approximately 90% for

13 characteristic photon energies from an element of interest for

14 which a fluidic concentration is to be measured ~~by said system~~;

15   electrical conductivity of 10-40 mOhms-cm when fabricated

16 into a ¼ mm thick electrode;

17   the ability to contain approximately at least 0.1% by weight

18 of foreign material relative to said high surface area material

19 prior to saturation;

20   high structural rigidity wherein a displacement under the

21 flow of said fluid does not exceed approximately 0.25mm;

22   high wetting ability wherein an approximately ¼ mm thick

23 sheet of said high surface area material becomes substantially

24 wetted in less than approximately three seconds; and

25   freedom from metallic impurities in excess of approximately

26 .5 parts per million, when measured by <u>x-ray fluorescence</u> ~~XRF~~

27 analysis.

1   29.   (currently amended) The system of claim 28, said large

2   plurality of pores characterized by a specific surface area of at

3   least approximately 400 m²³/g.

1   30.   (currently amended) The system of claim 28, said large

2   plurality of pores characterized by a specific surface area of at

3   most approximately 1000 m²³/g.

1   31.   (currently amended) The system of claim 29, said large

2   plurality of pores characterized by a specific surface area of at

3   most approximately 1000 m²³/g.

1   32.   (currently amended) The system of claim 1, said upper high

2   surface area electrode and said lower high surface area electrode

15

3 | each comprising a high surface area material in turn comprising:

4 | an x-ray transparency greater than approximately 90% for

5 | characteristic photon energies from an element of interest for

6 | which a fluidic concentration is to be measured nano-cellular

7 | carbon.

1 | 33. (original) The system of claim 1, said upper high surface

2 | area electrode and said lower high surface area electrode each

3 | comprising a carbon aerogel.

1 | 34.   (currently amended) The system of claim 1, said upper

2 | high surface area electrode comprising a thickness less than

3 | approximately $\ell = 1/(\mu*\rho)$; wherein:

4 | ℓ designates an optical depth of said upper high surface

5 | area electrode when wetted with said fluid;

6 | μ designates a mass absorption coefficient of said high

7 | surface area electrode when wetted with said fluid; and

8 | ρ designates a density of said high surface area electrode

9 | when wetted with said fluid.

1 | 35. (currently amended) The system of claim 34, said lower high

2 | surface area electrode comprising a thickness less than

3 | approximately $\ell = 1/(\mu*\rho)$; wherein:

4 | ℓ designates an optical depth of said lower high surface

5 | area electrode when wetted with said fluid;

6 | μ designates a mass absorption coefficient of said lower

7 | surface area electrode when wetted with said fluid; and

16

8   ρ designates a density of said lower surface area electrode

9   when wetted with said fluid. ~~matching said thickness of said~~

10 ~~upper high surface area electrode by approximately ± 10%.~~

1   36.   (currently amended) The system of claim 1, said

2   calibration data comprising:~~ionic preconcentration cell further~~

3 ~~comprising background data associated therewith:~~

4   ~~said~~ background data ~~comprising data~~ related to a rate at

5   which photons are detected to be emitted from at least one

6   background data energy channel of said preconcentration cell or

7   an equivalent cell, when said preconcentration cell or equivalent

8   cell is filled with a highly purified form of a fluid of interest

9   and exposed to x-rays.

1   37.   (currently amended) The system of claim 1, said

2   calibration data further comprising:~~ionic preconcentration cell~~

3 ~~further comprising sensitivity data associated therewith:~~

4   ~~said~~ sensitivity data ~~comprising data~~ related to a rate at

5   which photons are detected to be emitted from at least one

6   sensitivity data energy channel of said preconcentration cell or

7   an equivalent cell, when said preconcentration cell or equivalent

8   cell is filled with a first calibration solution, containing at

9   least one element of interest in a ~~said~~ fluid of interest in

10 known concentration above a minimum detection level of x-ray

11 detection equipment to be used for said detecting and measuring,

12 and when said preconcentration cell or equivalent cell is exposed

13 to x-rays.

1   38.   (currently amended) The system of claim 2, said

2   calibration data further comprising:~~ionic preconcentration cell~~

17

3 ~~further comprising ion extraction rate data acquired from and~~

4 ~~associated therewith:~~

5   ~~said~~ ion extraction rate data ~~comprising data~~ related to a

6 rate at which photons are detected to be emitted from ~~said~~ at

7 least one ion extraction rate data energy channel of said

8 preconcentration cell or an equivalent cell, when a ~~second~~

9 calibration solution, containing said at least one element of

10 interest in a ~~said~~ fluid of interest in known concentration below

11 a ~~said~~ minimum detection level of x-ray detection equipment to be

12 used for said detecting and measuring, is flowed through the ~~said~~

13 central flow interelectrode gap of said preconcentration cell or

14 equivalent cell, at a substantially constant flow rate, while the

15 ~~said~~ voltage application means applies the ~~said~~ voltage

16 differential across the ~~said~~ electrodes of said preconcentration

17 cell or equivalent cell, below an electrochemical potential of

18 said at least one element of interest and below an electrolysis

19 potential of said second calibration solution, and when said

20 preconcentration cell or equivalent cell is exposed to x-rays.

1 39.   (currently amended) The system of claim 2, said

2 calibration data further comprising: ~~ionic preconcentration cell~~

3 ~~further comprising background data, sensitivity data, and ion~~

4 ~~extraction rate data acquired from and associated therewith:~~

5   ~~said~~ background data ~~comprising data~~ related to a rate at

6 which photons are detected to be emitted from at least one

7 background data energy channel of said preconcentration cell or

8 an equivalent cell, when said preconcentration cell or equivalent

9 cell is filled with a highly purified form of a fluid of interest

18

10   and exposed to x-rays;

11   ~~said~~ sensitivity data ~~comprising data~~ related to a rate at

12   which photons are detected to be emitted from at least one

13   sensitivity data energy channel of said preconcentration cell <u>or</u>

14   <u>equivalent cell,</u> when said preconcentration cell <u>or equivalent</u>

15   <u>cell</u> is filled with a first calibration solution<u>,</u> containing at

16   least one element of interest in said fluid of interest in known

17   concentration above a minimum detection level of x-ray detection

18   equipment to be used for said detecting and measuring, and <u>when</u>

19   <u>said preconcentration cell or equivalent cell is</u> exposed to x-

20   rays; and

21   ~~said~~ ion extraction rate data ~~comprising data~~ related to a

22   rate at which photons are detected to be emitted from ~~said~~ at

23   least one ion extraction rate data energy channel of said

24   preconcentration cell <u>or an equivalent cell,</u> when a second

25   calibration solution<u>,</u> containing said at least one element of

26   interest in said fluid of interest in known concentration below

27   said minimum detection level of x-ray detection equipment to be

28   used for said detecting and measuring<u>,</u> is flowed through <u>the</u> ~~said~~

29   central flow interelectrode gap <u>of said preconcentration cell or</u>

30   <u>equivalent cell,</u> at a substantially constant flow rate<u>,</u> while <u>the</u>

31   ~~said~~ voltage application means applies <u>the</u> ~~said~~ voltage

32   differential across <u>the</u> ~~said~~ electrodes <u>of said preconcentration</u>

33   <u>cell or equivalent cell,</u> below an electrochemical potential of

34   said at least one element of interest and below an electrolysis

35   potential of said second calibration solution, and <u>when said</u>

36   <u>preconcentration cell or equivalent cell</u> is exposed to x-rays.

19

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1   40.   (currently amended)   The system of claim 2, further

2   comprising:

3   test data accumulation means for obtaining said test data

4   comprising data related to a rate at which photons are detected

5   to be emitted from ~~said~~ at least one energy channel of said

6   preconcentration cell when said fluid, suspected to contain at

7   least one element of interest, is flowed through said central

8   flow interelectrode gap at a substantially constant flow rate,

9   while said voltage application means applies said voltage

10 differential across said electrodes below an electrochemical

11 potential of said at least one element of interest and below an

12 electrolysis potential of said fluid, and when said

13 preconcentration cell is exposed to x-rays.

1   41.   (original)   The system of claim 40, further comprising:

2   analysis means for analyzing said test data and deducing

3   therefrom a concentration in said fluid, if any, of the suspected

4   at least one element of interest.

1   42.   (currently amended)   The system of claim 39, further

2   comprising:

3   test data accumulation means for obtaining said test data

4   comprising data related to a rate at which photons are detected

5   to be emitted from ~~said~~ at least one energy channel of said

6   preconcentration cell when said fluid, suspected to contain at

7   least one element of interest, is flowed through said central

8   flow interelectrode gap at a substantially constant flow rate,

9   while said voltage application means applies said voltage

10 differential across said electrodes below an electrochemical

20

11 | potential of said at least one element of interest and below an

12 | electrolysis potential of said fluid, and <u>when said</u>

13 | <u>preconcentration cell</u> is exposed to x-rays.

1 | 43.   (original) The system of claim 42, further comprising:

2 | analysis means for analyzing said test data in relation to

3 | said background data, said sensitivity data, and said ion

4 | extraction rate data, and deducing therefrom a concentration in

5 | said fluid, if any, of the suspected at least one element of

6 | interest.

1 | 44.   (currently amended) The system of claim <u>4</u>—2, further

2 | comprising:

3 | <u>voltage application means for applying a voltage</u>

4 | <u>differential between said upper high surface area electrode and</u>

5 | <u>said lower high surface area electrode while said fluid is</u>

6 | <u>flowing through said central flow interelectrode gap; and</u>

7 | x-ray source means <u>positioned and aligned relative to said</u>

8 | <u>upper x-ray transmission window</u> for exposing said

9 | preconcentration cell to x-rays <u>substantially transmitted through</u>

10 | <u>said upper x-ray transmission window,</u> while flowing said fluid

11 | and while applying said voltage differential.

1 | 45.   (currently amended) The system of claim 2, <u>said voltage</u>

2 | <u>application means</u> further comprising:

3 | a transportable voltage supply<u> for applying an electrostatic</u>

4 | <u>charge across said electrodes and thereby maintaining ions from</u>

5 | <u>said at least one element entrained in said electrodes during</u>

6 | <u>transport of said ionic preconcentration cell</u> ~~for continuing to~~

7 | ~~apply said voltage differential~~: after ceasing <u>flow of</u> ~~flowing~~

21

8 said fluid, while transporting said ionic preconcentration cell

9 to an x-ray source means for emitting x-rays toward said

10 preconcentration cell, and while exposing said preconcentration

11 cell to x-rays.

1 46. (original) The system of claim 1, further comprising:

2 flow control means for controlling a flow rate of said fluid

3 through said ionic preconcentration cell so as to maintain ε,

4 which designates a predetermined percentage of at least one

5 . element of interest to be extracted from said fluid, below

6 approximately 5% for said at least one element of interest.

1 47. (currently amended) The system of claim 46, wherein said

2 ε is maintained below an extraction percentage selected from <u>an</u>

3 ~~the~~ extraction percentage group consisting of approximately 4%,

4 3%, 2%<u>,</u> and 1%.

1 48. (currently amended) The system of claim 2, further

2 comprising flow control means for:

3 controlling a flow rate F of said fluid through said ionic

4 preconcentration cell and maintaining said F at a substantially

5 constant level so as to maintain ε, which designates a

6 predetermined percentage of at least one element of interest to

7 be extracted from said fluid and is specified by:

$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma\,\Phi}{q\,d}\,\frac{w_i}{w_f}\,\frac{A}{n_f\,C\,F} \times 100\% ,$$

9 below approximately 5% for said at least one element of interest;

10 wherein:

11 Γ_{ie} and Γ_{is} designate rates at which ions of said at least

12 one element of interest are respectively extracted from said

22

13 fluid by said cell and supplied to said cell by said fluid, σ

14 designates a composite conductivity of said fluid, Φ designates

15 a potential applied by said voltage application means across said

16 electrodes, d designates said predetermined interelectrode gap

17 width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$

18 Coulomb designates the unit charge, A designates an ordinary

19 surface area covered by said electrodes, n_f designates a number

20 density of said fluid, w_i and w_f designate atomic / molecular

21 weights, respectively, of said at least one element of interest

22 and of said fluid, and C designates a concentration of said at

23 least one element of interest in said fluid; and

24   for <u>having</u> said concentration C in a range where

25 conductivity varies substantially linearly with concentration,

26 with C in units of parts per billion, <u>wherein</u> σ is approximated

27 by:

28      $\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm}$.

1 49.   (original) The system of claim 48, wherein said ε is

2 maintained below an extraction percentage selected from the

3 extraction percentage group consisting of approximately 4%, 3%,

4 2% and 1%.

1 50.   (original) The system of claim 2, said voltage

2 application means applying said voltage differential across said

3 electrodes below an electrochemical potential of at least one

4 element of interest and below an electrolysis potential of said

5 fluid.

23

1 51. (currently amended) The system of claim 1, further

2 comprising:

3   leakage current monitoring means for <u>monitoring a total</u>

4 <u>concentration of dissolved ions in said upper and lower high</u>

5 <u>surface area electrodes while said electrodes are not saturated,</u>

6 ~~detecting a saturation state of said cell~~ by monitoring a leakage

7 current from said cell.

1 52. (original) The system of claim 51, further comprising:

2   ultra-low trace measuring means for measuring at least one

3 element of interest comprising ultra-low trace, high valence ions

4 in said fluid, based on said detecting said saturation state.

1 53. (currently amended) The system of claim 1, further

2 comprising:

3   leakage current monitoring means for<u>monitoring a total</u>

4 <u>concentration of dissolved ions in said upper and lower high</u>

5 <u>surface area electrodes while said electrodes are not saturated</u>

6 ~~estimating a concentration in said fluid of at least one element~~

7 ~~of interest by monitoring a leakage current in said cell~~; and

8   <u>flow rate adjustment</u> ~~time control~~ means for <u>adjusting the</u>

9 <u>flow of said fluid</u> ~~controlling how long said fluid flows~~ through

10 said ionic preconcentration cell <u>to control a percentage of said</u>

11 <u>ions extracted from said fluid,</u> based on <u>said monitoring said</u>

12 <u>leakage current</u> ~~the estimate obtained~~ by said leakage current

13 monitoring means.

1 54. (currently amended) The system of claim 1, further

2 comprising:

3   time control means for controlling how long said fluid flows

24

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4   through said ionic preconcentration cell based on setting an

5   impurity concentration C, in a range where conductivity varies

6   substantially linearly with concentration, to a predetermined

7   desired concentration detection level and flowing said fluid for

8   a time t given by:

9   $$t \propto \frac{S\ell}{\sigma} \propto \frac{S\ell}{C}; \text{ wherein:}$$

10   S designates a sensitivity of x-ray detection equipment to

11   be used for said detecting and measuring;

12   ℓ designates a thickness of said upper high surface area

13   electrode; and

14   σ designates a composite conductivity of said fluid.

1   55.   (currently amended)   The system of claim 1, further

2   comprising triggering means for triggering an action <u>in response</u>

3   <u>to</u> ~~when~~ said system detect<u>ing</u>~~s~~ that a concentration of at least

4   one element of interest in said fluid has passed a predetermined

5   threshold concentration.

1   56.   (currently amended)   The system of claim 55, further

2   comprising injection action means for injecting at least one

3   element into said fluid<u>, thereby maintaining said concentration</u>

4   <u>within a predetermined concentration range,</u> as said action in

5   response to said triggering means.

1   57.   (currently amended)   The system of claim 55, further

2   comprising dilution action means for diluting at least one

3   diluting fluid into said fluid<u>, thereby maintaining said</u>

4   <u>concentration within a predetermined concentration range,</u> as said

5   action in response to said triggering means.

25

ISIP017US

1   58.   (currently amended)   The system of claim 1, further

2   comprising:

3   ionic release means for cleaning said preconcentration cell

4   after use by releasing ~~said~~ ions accumulated within said high

5   specific surface area of said electrodes <u>into said fluid,</u> after

6   the accumulated ions have been exposed to x-rays and fluorescence

7   from said preconcentration cell has been detected.

1   59.   (currently amended)   The system of claim <u>4</u>~~1~~, further

2   comprising:

3   x-ray source means <u>positioned and aligned relative to said</u>

4   <u>upper x-ray transmission window</u> for emitting x-rays toward said

5   preconcentration cell <u>substantially transmitted through said</u>

6   <u>upper x-ray transmission window;</u> and

7   x-ray fluorescence detector means <u>positioned and aligned</u>

8   <u>relative to said upper x-ray transmission window</u> for detecting

9   fluoresced energy emitted by said preconcentration cell due to

10 said emitting ~~said~~ x-rays toward said preconcentration cell<u>,</u>

11 <u>through said upper x-ray transmission window</u>.

1   60.   (currently amended)   The system of claim 59, further

2   comprising:

3   <u>x-ray fluorescence</u> analysis means for analyzing the detected

4   <u>x-ray</u> fluoresced energy and deducing therefrom a concentration in

5   said fluid of at least one element of interest in said fluid.

1   61.   (currently amended)   The system of claim 1, further

2   comprising:

3   ~~telecommunications control means for controlling an~~

4   ~~operation of said ionic preconcentration cell using a~~

26

data from said ionic preconcentration cell.

1 62. (currently amended) A method for identifying ~~detecting~~
2 and measuring concentrations of elements in fluids, comprising
3 the steps of:
4 flowing a fluid through a central flow interelectrode gap of
5 an ionic preconcentration cell separating an upper high specific
6 surface area electrode from a lower high specific surface area
7 electrode of said ionic preconcentration cell by a predetermined
8 interelectrode gap width;
9 applying a voltage differential between said upper high
10 surface area electrode and said lower high surface area electrode
11 while said fluid is flowing through said central flow
12 interelectrode gap;
13 exposing said cell to x-rays under test conditions and
14 obtaining test data characterizing a response thereto of said
15 cell; and
16 deducing an identity, or measurement of concentration, of at
17 least one element in said fluid, using said test data in
18 combination with calibration data associated with said cell
19 characterizing a response from said cell when said cell or an
20 equivalent cell is exposed to x-rays under calibration
21 conditions.
1 63. (currently amended) The method of claim 62, said step of
2 applying said voltage differential further comprising the step
3 of:
4 applying an electrostatic charge across said electrodes and

27

5 thereby maintaining ions from said at least one element entrained

6 in said electrodes during transport of said ionic

7 preconcentration cell, ~~supplying said voltage differential~~ using

8 a transportable voltage supply.

1 64.   (currently amended) The method of claim 62, further

2 comprising the step of:

3   intimately contacting an upper surface of said upper high

4 surface area electrode with an upper x-ray transmission window of

5 said ionic preconcentration cell.

1 65.   (currently amended) The method of claim 64, further

2 comprising the step of:

3   intimately contacting a lower surface of said lower high

4 surface area electrode with a lower x-ray transmission window of

5 said ionic preconcentration cell.

1 66.   (original) The method of claim 62, further comprising the

2 steps of:

3   entering a fluid into said ionic preconcentration cell using

4 inlet flow means therefor; and

5   enabling said fluid to flow through said central flow

6 interelectrode gap.

1 67.   (currently amended) The method of claim 66, said step of

2 entering said fluid further comprising entering said fluid

3 through said inlet flow means comprising at least one inlet flow

4 slot substantially coplanar with said central flow interelectrode

5 gap.

1 68.   (currently amended) The method of claim 66, said step of

2 entering said fluid further comprising entering said fluid

28

3   through said inlet flow means comprising a plurality of inlet

4   flow tubes substantially coplanar with said central flow

5   interelectrode gap and substantially parallel with one another.

1   69.   (currently amended) The method of claim 66, further

2   comprising the step of enhancing a turbulence of the flow of said

3   fluid while entering said fluid, thereby inducing mixing of said

4   flow for enabling uniform extraction of said at least one element

5   from the flow stream.

1   70.   (currently amended) The method of claim 66, further

2   comprising the step of cleaning debris from said inlet flow means

3   using access ~~debris cleaning~~ means ~~there~~for accessing said inlet

4   flow means.

1   71.   (original) The method of claim 62, further comprising the

2   step of:

3   exiting said fluid out from said ionic preconcentration cell

4   after   said   fluid   has   flowed   through   said   central   flow

5   interelectrode gap using outlet flow means therefor.

1   72.   (currently amended) The method of claim 71, said step of

2   exiting said fluid further comprising exiting said fluid through

3   said outlet flow means comprising at least one outlet flow slot

4   substantially coplanar with said central flow interelectrode gap.

1   73.   (currently amended) The method of claim 71, said step of

2   exiting said fluid further comprising exiting said fluid through

3   said outlet flow means comprising a plurality of outlet flow

4   tubes substantially coplanar with said central flow

5   interelectrode gap and substantially parallel with one another.

1   74.   (currently amended)   The method of claim 71, further

2   comprising the step of cleaning debris from said outlet flow

3   means using access ~~debris-cleaning~~ means ~~there~~for accessing said

4   inlet flow means.

1   75.   (currently amended)   The method of claim 64 ~~62~~, further

2   comprising the step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

5   to one another, using ~~embodying~~ a body of said ionic

6   preconcentration cell comprising ~~in~~ a material comprising:

7   substantially no conductivity;

8   resistance to ionic leaching; and

9   resistance to radiation degradation from x-rays to

10   which said preconcentration cell is to be exposed.

1   76.   (currently amended)   The method of claim 64 ~~62~~, further

2   comprising the step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

5   to one another, using ~~embodying~~ a body of said ionic

6   preconcentration cell comprising ~~in~~ a material selected from a

7   ~~the~~ material group consisting of: plastic, glass, and fiberglass.

1   77.   (currently amended)   The method of claim 64 ~~62~~, further

2   comprising the step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

5   to one another, using ~~embodying~~ a body of said ionic

6   preconcentration cell comprising ~~in~~ a material comprising a non-

30

7 conducting, machinable polymer substantially resistant to

8 radiation degradation~~Delrin® plastic~~.

1 78.   (currently amended) The method of claim 62, further

2 comprising the step of:

3   providing said upper high surface area electrode with an

4 upper   electrode   thickness   thereof   less   than   or   equal   to

5 approximately $\ell = 1/\underline{(\mu * \rho)}$, wherein:

6   ℓ designates ~~is~~ an optical depth of said upper high surface

7 area electrode when wetted with ~~in said fluid of a characteristic~~

8 ~~photonic energy from~~ an element of interest for which a fluidic

9 concentration is to be measured ~~by said method~~, in said fluid;

10   μ designates ~~is~~ a mass absorption coefficient of said upper

11 high surface area electrode, when wetted with said element of

12 interest in said fluid; and

13   ρ designates ~~is~~ a material density of said upper high

14 surface area electrode, when wetted with said element of interest

15 in said fluid.

1 79.   (currently amended) The method of claim 78, further

2 comprising the step of:

3   providing said lower high surface area electrode with a

4 lower electrode thickness thereof less than or equal to

5 approximately $\ell = 1/\underline{(\mu * \rho)}$, wherein:

6   ℓ designates ~~is~~ an optical depth of said lower high surface

7 area electrode when wetted with ~~in said fluid of a characteristic~~

8 ~~photonic energy from~~ an element of interest for which a fluidic

9 concentration is to be measured ~~by said method~~, in said fluid;

31

ISIP017US

10   μ designates is a mass absorption coefficient of said lower

11 high surface area electrode, when wetted with said element of

12 interest·in said fluid; and

13   ρ designates is a material density of said lower high

14 surface area electrode, when wetted with said element of interest

15 in said fluid.

1   80.   (original)   The method of claim 62, further comprising the

2   step of:

3   providing ordinary surface areas of said upper high surface

4   area electrode and said lower high surface area electrode

5   approximately equal to an interrogation spot area of x-rays to

6   which said preconcentration cell is to be exposed.

1   81.   (currently amended)   The method of claim 64, further

2   comprising the step of:

3   providing a surface area of said upper x-ray transmission

4   window approximately equal to an interrogation spot area of x-

5   rays to which said preconcentration cell is to be exposed.

1   82.   (currently amended)   The method of claim 62, further

2   comprising the step of:

3   providing said central flow interelectrode gap comprising

4   said predetermined interelectrode gap width, designated d, within

5   an interelectrode gap range specified by:

6
$$d = \frac{\sigma \, \Phi}{q\varepsilon} \frac{w_i}{w_f} \frac{A}{n_f \, CF} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q\varepsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\varepsilon F} \; ; \text{ wherein:}$$

7   ε designates a predetermined percentage of at least one

8   element of interest to be extracted from said fluid, σ designates

32

11 '" Coulomb designates the unit charge, A designates an ordinary

12 surface area covered by said electrodes, n_f designates a number

13 density of said fluid, w_i and w_f designate atomic / molecular

14 weights, respectively, of said at least one element of interest

15 and of said fluid, C designates a concentration of said at least

16 one element of interest in said fluid, and F designates a flow

17 rate of said fluid through said ionic preconcentration cell;

18   said high surface area electrodes further comprise said

19 ordinary surface area A approximately equal to an interrogation

20 spot area of x-rays to which said preconcentration cell is to be

21 exposed;

22   said ε is chosen to be below approximately 5% for said at

23 least one element of interest;

24   said Φ is chosen to be below an electrochemical potential of

25 said at least one element of interest and below an electrolysis

26 potential of said fluid;

27   said F is chosen to exert no more than approximately .1 atm

28 of pressure upon an upper x-ray transmission window of said ionic

29 preconcentration cell in intimate contact with an upper surface

30 of said upper high surface area electrode;

31   said n_f and said w_f are chosen with reference to said at

32 least one element of interest; and

33   said w_i is chosen with reference to said fluid.

1   83.   (currently amended)   The method of claim 82 ~~62~~, further

2   comprising the step of:

33

ISIP017US

3   providing said central flow interelectrode gap comprising

4   said predetermined interelectrode gap width, ~~designated~~ d, with:

5   a minimum gap width selected from a ~~the~~ minimum gap width

6   group consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

7   a maximum gap width selected from a ~~the~~ maximum gap width

8   group consisting of 2 mm, 5 mm, and 10 mm.

1   84.   (currently amended) The method of claim 64, further

2   comprising the step of providing said upper x-ray transmission

3   window comprising:

4   an atomic number below 10;

5   structural rigidity to support up to 1/10 atm. of pressure

6   without bowing more than approximately 100 microns;

7   substantial impermeability relative to said fluid;

8   x-ray transparency greater than 90% for characteristic

9   photon energies from an element of interest for which a fluidic

10   concentration is to be measured ~~by said method~~;

11   x-ray scattering therefrom minimized to less than

12   approximately 10% of radiation scattered from a column of said

13   fluid equal to one optical depth in said fluid of a

14   characteristic photonic energy from an element of interest for

15   which a fluidic concentration is to be measured ~~by said method~~;

16   and

17   freedom from any single contaminant in excess of 1 part per

18   million, when measured by x-ray fluorescence.

1   85.   (currently amended) The method of claim 65, further

2   comprising the step of providing said lower x-ray transmission

3   window comprising:

34

4   an atomic number below 10;

5   structural rigidity to support up to 1/10 atm. of pressure

6   without bowing more than approximately 100 microns;

7   substantial impermeability relative to said fluid;

8   x-ray transparency greater than 90% for characteristic

9   photon energies from an element of interest for which a fluidic

10   concentration is to be measured by said method;

11   x-ray scattering therefrom minimized to less than

12   approximately 10% of radiation scattered from a column of said

13   fluid equal to one optical depth in said fluid of a

14   characteristic photonic energy from an element of interest for

15   which a fluidic concentration is to be measured by said method;

16   and

17   freedom from any single contaminant in excess of 1 part per

18   million, when measured by x-ray fluorescence.

1   86.   (currently amended)   The method of claim 64, further

2   comprising the step of:

3   providing said upper x-ray transmission window comprising a

4   polyimid film comprising structural rigidity to support up to

5   1/10 atm. of pressure without bowing more than approximately 100

6   micronsKapton®.

1   87.   (currently amended)   The method of claim 65, further

2   comprising the step of:

3   providing said lower x-ray transmission window comprising a

4   polyimid film comprising structural rigidity to support up to

5   1/10 atm. of pressure without bowing more than approximately 100

6   micronsKapton®.

35

1 88.   (currently amended) The method of claim 62 further

2 comprising the step of:

3   providing said upper high surface area electrode and said

4 lower high surface area electrode each comprising a high surface

5 area material in turn comprising:

6   a large plurality of pores characterized by a specific

7 surface area of at least approximately 100 m^{23}/g;

8   an average pore diameter of said pores between approximately

9 30 nm and 10 nm per pore;

10   a distribution of the said pore diameters grouped with a

11 standard deviation of less than approximately 10nm around said

12 average pore diameter;

13   an x-ray transparency greater than approximately 90% for

14 characteristic photon energies from an element of interest for

15 which a fluidic concentration is to be measured by said method;

16   electrical conductivity of 10-40 mOhms-cm when fabricated

17 into a ¼ mm thick electrode;

18   the ability to contain approximately at least 0.1% by weight

19 of foreign material relative to said high surface area material

20 prior to saturation;

21   high structural rigidity wherein a displacement under the

22 flow of said fluid does not exceed approximately 0.25mm;

23   high wetting ability wherein an approximately ¼ mm thick

24 sheet of said high surface area material becomes substantially

25 wetted in less than approximately three seconds; and

26   freedom from metallic impurities in excess of approximately

27 .5 parts per million, when measured by x-ray fluorescence XRF

36

1   89.   (currently amended)   The method of claim 88, said large

2   plurality of pores characterized by a specific surface area of at

3   least approximately 400 m²³/g.

1   90.   (currently amended)   The method of claim 88, said large

2   plurality of pores characterized by a specific surface area of at

3   most approximately 1000 m²³/g.

1   91.   (currently amended)   The method of claim 89, said large

2   plurality of pores characterized by a specific surface area of at

3   most approximately 1000 m²³/g.

1   92.   (currently amended)   The method of claim 62, further

2   comprising the step of:

3   providing said upper high surface area electrode and said

4   lower high surface area electrode each comprising a high surface

5   area material in turn comprising:

6   an x-ray transparency greater than approximately 90% 'for

7   characteristic photon energies from an element of interest for

8   which a fluidic concentration is to be measured~~nano-cellular~~

9   ~~carbon~~.

1   93.   (original)   The method of claim 62, further comprising the

2   step of:

3   providing said upper high surface area electrode and said

4   lower high surface area electrode each comprising a carbon

5   aerogel.

1   94.   (currently amended)   The method of claim 62, further

2   comprising the step of:

3   providing said upper high surface area electrode with a

37

ℓ designates an optical depth of said upper high surface

6 area electrode when wetted with said fluid;

7 μ designates a mass absorption coefficient of said high

8 surface area electrode when wetted with said fluid; and

9 ρ designates a density of said high surface area electrode

10 when wetted with said fluid.

1 95. (currently amended) The method of claim 94, further

2 comprising the step of:

3 providing said lower high surface area electrode with a

4 thickness less than approximately $\ell = 1/(\mu*\rho)$; wherein:

5 ℓ designates an optical depth of said lower high surface

6 area electrode when wetted with said fluid;

7 μ designates a mass absorption coefficient of said lower

8 surface area electrode when wetted with said fluid; and

9 ρ designates a density of said lower surface area electrode

10 when wetted with said fluid.

11 ~~matching said thickness of said upper high surface area~~

12 ~~electrode by approximately ± 10%.~~

1 96. (currently amended) The method of claim 62, further

2 comprising the step of obtaining said calibration data by:~~—~~

3 ~~acquiring background data from said ionic preconcentration cell~~

4 ~~and associating said data therewith:~~

5 ~~said step of acquiring said background data comprising the~~

6 ~~steps of:~~

7 ~~————~~filling said preconcentration cell or an equivalent

38

8 | cell, with a highly purified form of a fluid of interest;

9 | ————exposing the filled ~~said~~ preconcentration cell or

10 | equivalent cell to x-rays; ~~and~~

11 | ————acquiring ~~said~~ background data related to a rate at

12 | which photons are detected to be emitted from at least one

13 | background data energy channel of said preconcentration cell or

14 | equivalent cell; and

15 | associating said background data with said preconcentration

16 | cell.

1 | 97.   (currently amended) The method of claim 62, further

2 | comprising the step of obtaining said calibration data by:—

3 | ~~acquiring sensitivity data from said ionic preconcentration cell~~

4 | ~~and associating said data therewith:~~

5 | ~~said step of acquiring said sensitivity data comprising the~~

6 | ~~steps of:~~

7 | ————filling said preconcentration cell or an equivalent

8 | cell, with a first calibration solution containing at least one

9 | element of interest in a ~~said~~ fluid of interest in known

10 | concentration above a minimum detection level of x-ray detection

11 | equipment to be used for said detecting and measuring;

12 | ————exposing the filled ~~said~~ preconcentration cell or

13 | equivalent cell to x-rays; ~~and~~

14 | ————acquiring ~~said~~ sensitivity data related to a rate at

15 | which photons are detected to be emitted from at least one

16 | sensitivity data energy channel of said preconcentration cell or

17 | equivalent cell; and

18 | associating said sensitivity data with said preconcentration

39

1 ~~comprising the step of obtaining said calibration data by:~~

3 ~~acquiring ion extraction rate data from said ionic~~

4 ~~preconcentration cell and associating said data therewith:~~

5 ~~said step of acquiring said ion extraction rate data~~

6 ~~comprising the steps of:~~

7 ————applying said voltage differential across the ~~said~~

8 electrodes of said preconcentration cell or an equivalent cell,

9 below an electrochemical potential of said at least one element

10 of interest and below an electrolysis potential of a ~~said second~~

11 calibration solution;

12 ————flowing said ~~a second~~ calibration solution containing

13 said at least one element of interest in a ~~said~~ fluid of interest

14 in known concentration below a ~~said~~ minimum detection level of x-

15 ray detection equipment to be used for said detecting and

16 measuring through the ~~said~~ central flow interelectrode gap of

17 said preconcentration cell or equivalent cell at a substantially

18 constant flow rate;

19 ————exposing said preconcentration cell or equivalent cell

20 with said ~~second~~ calibration solution therein to x-rays; ~~and~~

21 ————acquiring ~~said~~ ion extraction rate data related to a

22 rate at which photons are detected to be emitted from ~~said~~ at

23 least one ion extraction rate data energy channel of said

24 preconcentration cell or equivalent cell; and

25 associating said ion extraction rate data with said

26 preconcentration cell.

40

19 | cell.

1 98.   (currently amended) The method of claim 62, further

2 comprising the step of obtaining said calibration data by:—

3 acquiring ion extraction rate data from said ionic

4 preconcentration cell and associating said data therewith:

5 —   said step of acquiring said ion extraction rate data

6 comprising the steps of:

7 ——applying said voltage differential across the said

8 electrodes of said preconcentration cell or an equivalent cell,

9 below an electrochemical potential of said at least one element

10 of interest and below an electrolysis potential of a said second

11 calibration solution;

12 ——flowing said a second calibration solution containing

13 said at least one element of interest in a said fluid of interest

14 in known concentration below a said minimum detection level of x-

15 ray detection equipment to be used for said detecting and

16 measuring through the said central flow interelectrode gap of

17 said preconcentration cell or equivalent cell at a substantially

18 constant flow rate;

19 ——exposing said preconcentration cell or equivalent cell

20 with said second calibration solution therein to x-rays; and

21 ——acquiring said ion extraction rate data related to a

22 rate at which photons are detected to be emitted from said at

23 least one ion extraction rate data energy channel of said

24 preconcentration cell or equivalent cell; and

25   associating said ion extraction rate data with said

26 preconcentration cell.

40

1   99.   (currently amended) The method of claim 62, further

2   comprising the steps of obtaining said calibration data by:—

3   acquiring background data, sensitivity data, and ion extraction

4   rate data from said ionic preconcentration cell and associating

5   said data therewith:

6   —   said step of acquiring said background data comprising the

7   steps of:

8   ————filling said preconcentration cell or an equivalent

9   cell, with a highly purified form of a fluid of interest;

10   ————exposing the filled said preconcentration cell or

11 equivalent cell to x-rays; and

12   ————acquiring said background data related to a rate at

13 which photons are detected to be emitted from at least one

14 background data energy channel of said preconcentration cell or

15 equivalent cell;

16 —   said step of acquiring said sensitivity data comprising the

17 steps of:

18   ————filling said preconcentration cell or equivalent cell,

19 with a first calibration solution containing at least one element

20 of interest in said fluid of interest in known concentration

21 above a minimum detection level of x-ray detection equipment to

22 be used for said detecting and measuring;

23   ————exposing the filled said preconcentration cell or

24 equivalent cell to x-rays; and

25   ————acquiring said sensitivity data related to a rate at

26 which photons are detected to be emitted from at least one

27 sensitivity data energy channel of said preconcentration cell or

41

ISIP017US

28 | equivalent cell; ~~and~~

29 | ~~said step of acquiring said ion extraction rate data~~

30 | ~~comprising the steps of:~~

31 | ~~applying said voltage differential across the ~~said~~

32 | electrodes of said preconcentration cell or equivalent cell,

33 | below an electrochemical potential of said at least one element

34 | of interest and below an electrolysis potential of a ~~said~~ second

35 | calibration solution;

36 | flowing said ~~a~~ second calibration solution containing

37 | said at least one element of interest in said fluid of interest

38 | in known concentration below a ~~said~~ minimum detection level of x-

39 | ray detection equipment to be used for said detecting and

40 | measuring through the ~~said~~ central flow interelectrode gap of

41 | said preconcentration cell or equivalent cell, at a substantially

42 | constant flow rate;

43 | exposing said preconcentration cell or equivalent cell

44 | with said second calibration solution therein to x-rays; ~~and~~

45 | acquiring ~~said~~ ion extraction rate data related to a

46 | rate at which photons are detected to be emitted from ~~said~~ at

47 | least one ion extraction rate data energy channel of said

48 | preconcentration cell or equivalent cell; and

49 | associating said background data, said sensitivity data, and

50 | said ion extraction rate data with said preconcentration cell.

1 | 100.   (currently amended) The method of claim 62, further

2 | comprising the steps of:

3 | applying said voltage differential across said electrodes

4 | below an electrochemical potential of said at least one element

42

ISIP017US

5   of interest and below an electrolysis potential of said fluid,

6   suspected to contain at least one element of interest;

7   flowing said fluid through said central flow interelectrode

8   gap at a substantially constant flow rate;

9   exposing said preconcentration cell with said fluid therein

10   to x-rays; and

11   acquiring said test data related to a rate at which photons

12   are detected to be emitted from at least one test data energy

13   channel of said preconcentration cell.

1   101.   (original) The method of claim 100, further comprising

2   the step of:

3   analyzing said test data and deducing therefrom a

4   concentration in said fluid, if any, of the suspected at least

5   one element of interest.

1   102.   (currently amended) The method of claim 99, further

2   comprising the steps of:

3   applying said voltage differential across said electrodes

4   below an electrochemical potential of said at least one element

5   of interest and below an electrolysis potential of said fluid,

6   suspected to contain at least one element of interest;

7   flowing said fluid through said central flow interelectrode

8   gap at a substantially constant flow rate;

9   exposing said preconcentration cell with said fluid therein

10   to x-rays; and

11   acquiring said test data related to a rate at which photons

12   are detected to be emitted from at least one test data energy

13   channel of said preconcentration cell.

43

1   103.   (original)   The method of claim 102, further comprising

2   the step of:

3   analyzing said test data in relation to said background

4   data, said sensitivity data, and said ion extraction rate data,

5   and deducing therefrom a concentration in said fluid, if any, of

6   the suspected at least one element of interest. ,

1   104.   (currently amended)   The method of claim 62, further

2   comprising the steps of:

3   exposing said preconcentration cell to x-rays substantially

4   transmitted through said upper x-ray transmission window, while

5   flowing said fluid and while applying said voltage differential.

1   105.   (currently amended)   The method of claim 62, said step of

2   applying said voltage differential further comprising the steps

3   of:

4   ceasing flow of flowing said fluid while applying an

5   electrostatic charge across said electrodes and thereby

6   maintaining ions from said at least one element entrained in said

7   electrodes continuing to apply said voltage differential;

8   transporting said ionic preconcentration cell to an x-ray

9   source means for emitting x-rays toward said preconcentration

10   cell while continuing to applying said electrostatic

11   chargevoltage differential; and

12   exposing said preconcentration cell to x-rays from said x-

13   ray source means while continuing to applying said electrostatic

14   charge voltage differential.

1   106.   (currently amended)   The method of claim 62, further

2   comprising the step of:

44

3   controlling a flow rate of said fluid through said ionic

4   preconcentration cell so a<u>s</u> to maintain ε, which designates a

5   predetermined percentage of at least one element of interest to

6   be extracted from said fluid, below approximately 5% for said at

7   least one element of interest.

1   107.   (currently amended) The method of claim 106, further

2   comprising the step of:

3   maintaining said ε below an extraction percentage selected

4   from an ~~the~~ extraction percentage group consisting of

5   approximately 4%, 3%, 2%<u>,</u> and 1%.

1   108.   (currently amended) The method of claim 62, further

2   comprising the step of:

3   controlling a flow rate F of said fluid through said ionic

4   preconcentration cell and maintaining said F at a substantially

5   constant level so as to maintain ε, which designates a

6   predetermined percentage of at least one element of interest to

7   be extracted from said fluid and is specified by:

8
$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma\,\Phi}{q\,d}\,\frac{w_i}{w_f}\,\frac{A}{n_f\,CF} \times 100\%\,,$$

9   below approximately 5% for said at least one element of interest;

10   wherein:

11   Γ_{ie} and Γ_{is} designate rates at which ions of said at least

12   one element of interest are respectively extracted from said

13   fluid by said cell and supplied to said cell by said fluid, σ

14   designates a composite conductivity of said fluid, Φ designates

15   said voltage differential applied across said electrodes, d

16   designates said predetermined interelectrode gap width of said

45

17 central flow interelectrode gap, $q = 1.60 \times 10^{-19}$ Coulomb designates

18 the unit charge, A designates an ordinary surface area covered by

19 said electrodes, n_f designates a number density of said fluid,

20 w_i and w_f designate atomic / molecular weights, respectively, of

21 said at least one element of interest and of said fluid, and C

22 designates a concentration of said at least one element of

23 interest in said fluid; and

24   having for said concentration C in a range where

25 conductivity varies substantially linearly with concentration,

26 with C in units of parts per billion, wherein σ is approximated

27 by:

28          $\sigma \approx 2 \times 10^{-9} \, C / \text{Ohm} - \text{cm}$.

1   109.   (currently amended)   The method of claim 108, further

2   comprising the step of:

3   maintaining said ε below an extraction percentage selected

4   from an the extraction percentage group consisting of

5   approximately 4%, 3%, 2%, and 1%.

1   110.   (original)   The method of claim 62, further comprising the

2   step of:

3   applying said voltage differential across said electrodes

4   below an electrochemical potential of at least one element of

5   interest and below an electrolysis potential of said fluid.

1   111.   (original)   The method of claim 62, further comprising the

2   step of:

3   monitoring a total concentration of dissolved ions in said

4   upper and lower high surface area electrodes while said

5   electrodes are not saturated, detecting a saturation state of

46

ISIP017US

6 | ~~said cell~~ by monitoring a leakage current from said cell.

1 112.   (original) The method of claim 111, further comprising

2 the step of:

3   measuring at least one element of interest comprising ultra-

4 low trace, high valence ions in said fluid, based on said

5 detecting said saturation state.

1 113.   (currently amended) The method of claim 62, further

2 comprising the steps of:

3   monitoring a total concentration of dissolved ions in said

4 upper and lower high surface area electrodes while said

5 electrodes are not saturated ~~estimating a concentration in said~~

6 ~~fluid of at least one element of interest~~ by monitoring a leakage

7 current in said cell; and

8   adjusting the flow of ~~controlling how long~~ said fluid ~~flows~~

9 through said ionic preconcentration cell to control a percentage

10 of said ions extracted from said fluid, based on ~~the estimate~~

11 ~~obtained by~~ said monitoring said leakage current ~~said leakage~~

12 ~~current monitoring means~~.

1 114.   (currently amended) The method of claim 62 ~~1~~, further

2 comprising the steps of:

3   setting an impurity concentration C, in a range where

4 conductivity varies substantially linearly with concentration, to

5 a predetermined desired concentration detection level; and

6   controlling how long said fluid flows through said ionic

7 preconcentration cell by flowing said fluid for a time t given

8 by:

47

ISIP017US

9    $t \propto \dfrac{S\ell}{\sigma} \propto \dfrac{S\ell}{C}$, wherein:

10   S designates a sensitivity of x-ray detection equipment to

11   be used for said detecting and measuring;

12   ~~ℓ~~ designates a thickness of said upper high surface area

13   electrode; and

14   σ designates a composite conductivity of said fluid.

1   115.   (currently amended)   The method of claim 62, further

2   comprising the step of:

3   triggering an action in response to detecting ~~when said~~

4   ~~method detects~~ that a concentration of at least one element of

5   interest in said fluid has passed a predetermined threshold

6   concentration.

1   116.   (currently amended)   The method of claim 115, said step of

2   triggering further comprising the step~~s~~ of:

3   maintaining said concentration within a predetermined

4   concentration range by injecting at least one element into said

5   fluid as said action in response to said detecting ~~triggering~~.

1   117.   (currently amended)   The method of claim 115, said step of

2   triggering further comprising the step~~s~~ of:

3   maintaining said concentration within a predetermined

4   concentration range by diluting at least one diluting fluid into

5   said fluid as said action in response to said detecting

6   ~~triggering~~.

1   118.   (currently amended)   The method of claim 62, further

2   comprising the step of:

3   cleaning said preconcentration cell after use by releasing

48

ISIP017US

4   ~~said~~ ions accumulated within said high specific surface area of

5   said electrodes into said fluid, after the accumulated ions have

6   been exposed to x-rays and fluorescence from said

7   preconcentration cell has been detected.

1   119.   (currently amended)   The method of claim 64 ~~62~~, further

2   comprising the steps of:

3   emitting x-rays toward said preconcentration cell

4   substantially transmitted through said upper x-ray transmission

5   window; and

6   detecting fluoresced energy emitted by said preconcentration

7   cell due to said emitting ~~said~~ x-rays toward said

8   preconcentration cell, through said upper x-ray transmission

9   window.

1   120.   (currently amended)   The method of claim 119, further

2   comprising the step of:

3   analyzing the detected x-ray fluoresced energy and deducing

4   therefrom a concentration in said fluid of at least one element

5   of interest in said fluid.

1   121.   (currently amended)   The method of claim 62, further

2   comprising the step of:

3   downloading and analyzing said test data from ~~controlling an~~

4   ~~operation of~~ said ionic preconcentration cell using a

5   telecommunications link.

1   122.   (new)   The system of claim 3, wherein:

2   said transportable voltage supply is embedded into a body of

3   said ionic preconcentration cell.

1   123.   (new)   The method of claim 63, further comprising the step

49

2   of:

3   providing said transportable voltage supply embedded into a

4   body of said ionic preconcentration cell.

1   124.   (new)   An ionic preconcentration cell apparatus for

2   identifying and measuring concentrations of elements in fluids,

3   comprising:

4   an upper high surface area electrode comprising a high

5   specific surface area thereof;

6   a lower high surface area electrode comprising a high

7   specific surface area thereof, substantially parallel to said

8   upper high surface area electrode;

9   a central flow interelectrode gap separating said upper and

10 lower high surface area electrodes by a predetermined

11 interelectrode gap width;

12   fluid flow means for flowing a fluid through said central

13 flow interelectrode gap; and

14   an upper x-ray transmission window in intimate contact with

15 an upper surface of said upper high surface area electrode.

1   125.   (new)   The apparatus of claim 124, further comprising:

2   voltage application means for applying a voltage

3   differential between said upper high surface area electrode and

4   said lower high surface area electrode while said fluid is

5   flowing through said central flow interelectrode gap.

1   126.   (new)   The apparatus of claim 125, said voltage

2   application means further comprising:

3   a transportable voltage supply connected across said upper

4   and lower high surface area electrodes for applying an

50

5   electrostatic charge across said electrodes and thereby

6   maintaining ions from said at least one element entrained in said

7   electrodes during transport of said ionic preconcentration cell.

1   127.   (new) The apparatus of claim 126, wherein:

2   said transportable voltage supply is embedded into a body of

3   said ionic preconcentration cell.

1   128.   (new) The apparatus of claim 125, said voltage

2   application means further comprising:

3   a transportable voltage supply for applying an electrostatic

4   charge across said electrodes and thereby maintaining ions from

5   said at least one element entrained in said electrodes during

6   transport of said ionic preconcentration cell: after ceasing flow

7   of said fluid, while transporting said ionic preconcentration

8   cell to an x-ray source means for emitting x-rays toward said

9   preconcentration cell, and while exposing said preconcentration

10 cell to x-rays.

11 129.   (new) The apparatus of claim 125, further comprising:

2   x-ray source means positioned and aligned relative to said

3   upper x-ray transmission window for exposing said

4   preconcentration cell to x-rays substantially transmitted through

5   said upper x-ray transmission window, while flowing said fluid

6   and while applying said voltage differential.

1   130.   (new) The apparatus of claim 124, further comprising:

2   a lower x-ray transmission window in intimate contact with a

3   lower surface of said lower high surface area electrode.

1   131.   (new) The apparatus of claim 124, further comprising:

2   x-ray source means positioned and aligned relative to said

51

3   upper x-ray transmission window for emitting x-rays toward said

4   preconcentration cell substantially transmitted through said

5   upper x-ray transmission window.

1   132.   (new)   The apparatus of claim 131, further comprising:

2   x-ray fluorescence detector means positioned and aligned

3   relative to said upper x-ray transmission window for detecting

4   fluoresced energy emitted by said preconcentration cell due to

5   said emitting x-rays toward said preconcentration cell, through

6   said upper x-ray transmission window.

1   133.   (new)   The apparatus of claim 132, further comprising:

2   x-ray fluorescence analysis means for analyzing the detected

3   x-ray fluoresced energy and deducing therefrom a concentration in

4   said fluid of at least one element of interest in said fluid.

1   134.   (new)   The apparatus of claim 124, further comprising:

2   a cell collector body maintaining a position of said upper

3   and lower high surface area electrodes and said upper x-ray

4   transmission window relative to one another, said cell collector

5   body in turn comprising a material comprising:

6   substantially no conductivity;

7   resistance to ionic leaching; and

8   resistance to radiation degradation from x-rays to

9   which said preconcentration cell is to be exposed.

1   135.   (new)   The apparatus of claim 124, further comprising:

2   a cell collector body maintaining a position of said upper

3   and lower high surface area electrodes and said upper x-ray

4   transmission window relative to one another, said cell collector

5   body comprising a material selected from a material group

52

6   consisting of: plastic, glass, and fiberglass.

1   136.   (new)   The apparatus of claim 124, further comprising:

2   a cell collector body maintaining a position of said upper

3   and lower high surface area electrodes and said upper x-ray

4   transmission window relative to one another, said cell collector

5   body comprising a non-conducting, machinable polymer

6   substantially resistant to radiation degradation.

1   137.   (new)   The apparatus of claim 124, said upper high surface

2   area electrode and said lower high surface area electrode further

3   comprising an ordinary surface area approximately equal to an

4   interrogation spot area of x-rays to which said preconcentration

5   cell is to be exposed.

1   138.   (new)   The apparatus of claim 124, said upper x-ray

2   transmission window comprising a surface area approximately equal

3   to an interrogation spot area of x-rays to which said

4   preconcentration cell is to be exposed.

1   139.   (new)   The apparatus of claim 124, said upper x-ray

2   transmission window comprising:

3   an atomic number below 10;

4   structural rigidity to support up to 1/10 atm. of pressure

5   without bowing more than approximately 100 microns;

6   substantial impermeability relative to said fluid;

7   x-ray transparency greater than 90% for characteristic

8   photon energies from an element of interest for which a fluidic

9 . concentration is to be measured;

10   x-ray scattering therefrom minimized to less than

11   approximately 10% of radiation scattered from a column of said

53

12   fluid equal to one optical depth in said fluid of a

13   characteristic photonic energy from an element of interest for

14   which a fluidic concentration is to be measured; and

15   freedom from any single contaminant in excess of 1 part per

16   million, when measured by x-ray fluorescence.

1   140.   (new)   The apparatus of claim 130, said lower x-ray

2   transmission window comprising:

3   an atomic number below 10;

4   structural rigidity to support up to 1/10 atm. of pressure

5   without bowing more than approximately 100 microns;

6   substantial impermeability relative to said fluid;

7   x-ray transparency greater than 90% for characteristic

8   photon energies from an element of interest for which a fluidic

9   concentration is to be measured;

10   x-ray scattering therefrom minimized to less than

11   approximately 10% of radiation scattered from a column of said

12   fluid equal to one optical depth in said fluid of a

13   characteristic photonic energy from an element of interest for

14   which a fluidic concentration is to be measured; and

15   freedom from any single contaminant in excess of 1 part per

16   million, when measured by x-ray fluorescence.

1   141.   (new)   The apparatus of claim 124, said upper x-ray

2   transmission window comprising a polyimid film comprising

3   structural rigidity to support up to 1/10 atm. of pressure

4   without bowing more than approximately 100 microns.

1   142.   (new)   The apparatus of claim 130, said lower x-ray

2   transmission window comprising a polyimid film comprising

54

3   structural rigidity to support up to 1/10 atm. of pressure

4   without bowing more than approximately 100 microns.

1   143.   (new) A method for identifying and measuring

2   concentrations of elements in fluids, comprising the steps of:

3   flowing a fluid through a central flow interelectrode gap of

4   an ionic preconcentration cell separating an upper high specific

5   surface area electrode from a lower high specific surface area

6   electrode of said ionic preconcentration cell by a predetermined

7   interelectrode gap width;

8   applying a voltage differential between said upper high

9   surface area electrode and said lower high surface area electrode

10   while said fluid is flowing through said central flow

11   interelectrode gap;

12   passing x-rays through an upper x-ray transmission window

13   intimately contacting an upper surface of said upper high surface

14   area electrode; and

15   deducing an identity, or measurement of concentration, of at

16   least one element in said fluid based on a response of said

17   preconcentration cell to said x-rays.

1   144.   (new) The method of claim 143, said step of applying said

2   voltage differential further comprising the step of:

3   applying an electrostatic charge across said electrodes and

4   thereby maintaining ions from said at least one element entrained

5   in said electrodes during transport of said ionic

6   preconcentration cell, using a transportable voltage supply.

1   145.   (new) The method of claim 144, further comprising the

2   step of:

55

3   providing said transportable voltage supply embedded into a

4   body of said ionic preconcentration cell.

1   146.   (new)   The method of claim 143, said step of applying said

2   voltage differential further comprising the steps of:

3   ceasing flow of said fluid while applying an electrostatic

4   charge across said electrodes and thereby maintaining ions from

5   said at least one element entrained in said electrodes;

6   transporting said ionic preconcentration cell to an x-ray

7   source means for emitting x-rays toward said preconcentration

8   cell while applying said electrostatic charge; and

9   exposing said preconcentration cell to x-rays from said x-

10   ray source means while applying said electrostatic charge.

1   147.   (new)   The method of claim 143, further comprising the

2   steps of:

3   exposing said preconcentration cell to x-rays substantially

4   transmitted through said upper x-ray transmission window, while

5   flowing said fluid and while applying said voltage differential.

1   148.   (new)   The method of claim 143, further comprising the

2   step of:

3   passing said x-rays through a lower x-ray transmission

4   window intimately contacting a lower surface of said lower high

5   surface area electrode.

1   149.   (new)   The method of claim 143, further comprising the

2   step of:

3   emitting x-rays toward said preconcentration cell

4   substantially transmitted through said upper x-ray transmission

5   window.

56

ISIP017US

1   150.   (new)   The method of claim 149, further comprising the

2   step of:

3   detecting fluoresced energy emitted by said preconcentration

4   cell due to said emitting x-rays toward said preconcentration

5   cell, through said upper x-ray transmission window.

1   151.   (new)   The method of claim 150, further comprising the

2   step of:

3   analyzing the detected x-ray fluoresced energy and deducing

4   therefrom a concentration in said fluid of at least one element

5   of interest in said fluid.

1   152.   (new)   The method of claim 143, further comprising the

2   step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

5   to one another, using a body of said ionic preconcentration cell

6   comprising a material comprising:

7   substantially no conductivity;

8   resistance to ionic leaching; and

9   resistance to radiation degradation from x-rays to

10   which said preconcentration cell is to be exposed.

1   153.   (new)   The method of claim 143, further comprising the

2   step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

5   to one another, using a body of said ionic preconcentration cell

6   comprising a material selected from a material group consisting

7   of: plastic, glass, and fiberglass.

57

1   154.   (new)   The method of claim 143, further comprising the

2   step of:

3   maintaining a position of said upper and lower high surface

4   area electrodes and said upper x-ray transmission window relative

5   to one another, using a body of said ionic preconcentration cell

6   comprising a material comprising a non-conducting, machinable

7   polymer substantially resistant to radiation degradation.

1   155.   (new)   The method of claim 143, further comprising the

2   step of:

3   providing ordinary surface areas of said upper high surface

4   area electrode and said lower high surface area electrode

5   approximately equal to an interrogation spot area of x-rays to

6   which said preconcentration cell is to be exposed.

1   156.   (new)   The method of claim 143, further comprising the

2   step of:

3   providing a surface area of said upper x-ray transmission

4   window approximately equal to an interrogation spot area of x-

5   rays to which said preconcentration cell is to be exposed.

1   157.   (new)   The method of claim 143, further comprising the

2   step of providing said upper x-ray transmission window

3   comprising:

4   an atomic number below 10;

5   structural rigidity to support up to 1/10 atm. of pressure

6   without bowing more than approximately 100 microns;

7   substantial impermeability relative to said fluid;

8   x-ray transparency greater than 90% for characteristic

9   photon energies from an element of interest for which a fluidic

58

ISIP017US

10   concentration is to be measured by said method;

11   x-ray scattering therefrom minimized to less than

12   approximately 10% of radiation scattered from a column of said

13   fluid equal to one optical depth in said fluid of a

14   characteristic photonic energy from an element of interest for

15   which a fluidic concentration is to be measured by said method;

16   and

17   freedom from any single contaminant in excess of 1 part per

18   million, when measured by x-ray fluorescence.

1   158.   (new) The method of claim 148, further comprising the

2   step of providing said lower x-ray transmission window

3   comprising:

4   an atomic number below 10;

5   structural rigidity to support up to 1/10 atm. of pressure

6   without bowing more than approximately 100 microns;

7   substantial impermeability relative to said fluid;

8   x-ray transparency greater than 90% for characteristic

9   photon energies from an element of interest for which a fluidic

10   concentration is to be measured by said method;

11   x-ray scattering therefrom minimized to less than

12   approximately 10% of radiation scattered from a column of said

13   fluid equal to one optical depth in said fluid of a

14   characteristic photonic energy from an element of interest for

15   which a fluidic concentration is to be measured by said method;

16   and

17   freedom from any single contaminant in excess of 1 part per

18   million, when measured by x-ray fluorescence.

59

ISIP017US

1   159.   (new)   The method of claim 143, further comprising the

2   step of:

3   providing said upper x-ray transmission window comprising a

4   polyimid film comprising structural rigidity to support up to

5   1/10 atm. of pressure without bowing more than approximately 100

6   microns.

1   160.   (new)   The method of claim 148, further comprising the

2   step of:

3   providing said lower x-ray transmission window comprising a

4   polyimid film comprising structural rigidity to support up to

5   1/10 atm. of pressure without bowing more than approximately 100

6   microns.

1   161.   (new)   A method of optimizing fabrication of an ionic

2   preconcentration cell for identifying and measuring

3   concentrations of elements in fluids; said ionic preconcentration

4   cell comprising an upper high surface area electrode comprising a

5   high specific surface area thereof; a lower high surface area

6   electrode comprising a high specific surface area thereof; and a

7   central flow interelectrode gap separating said upper and lower

8   high surface area electrodes by a predetermined interelectrode

9   gap width; said method comprising the step of:

10   optimizing said upper high surface area electrode with an

11   upper electrode thickness less than or equal to approximately an

12   optical depth ℓ of said upper high surface area electrode when

13   wetted with a fluid to be flowed through said cell.

1   162. (new)   The optimization method of claim 161, wherein:

2   said $\ell = 1/(\mu * \rho)$;

60

ISIP017US

3   μ designates a mass absorption coefficient of said upper

4 high surface area electrode when wetted with said fluid; and

5   ρ designates a material density of said upper high surface

6 area electrode when wetted with said fluid.

1 163.   (new) The optimization method of claim 161, further

2 comprising the step of:

3   optimizing said lower high surface area electrode with a

4 lower electrode thickness less than or equal to approximately an

5 optical depth ℓ of said lower high surface area electrode when

6 wetted with said fluid.

1 164.   (new) The optimization method of claim 163, wherein:

2   said $\ell = 1/(\mu * \rho)$;

3   μ designates a mass absorption coefficient of said lower

4 high surface area electrode when wetted with said fluid; and

5   ρ designates a material density of said lower high surface

6 area electrode when wetted with said fluid.

1 165.   (new) A method of optimizing fabrication of an ionic

2 preconcentration cell for identifying and measuring

3 concentrations of elements in fluids; said ionic preconcentration

4 cell comprising an upper high surface area electrode comprising a

5 high specific surface area thereof; a lower high surface area

6 electrode comprising a high specific surface area thereof; and a

7 central flow interelectrode gap separating said upper and lower

8 high surface area electrodes by a predetermined interelectrode

9 gap width; said method comprising the step of:

10   optimizing said upper high surface area electrode with an

61

11 upper electrode thickness less than or equal to approximately an

12 optical depth ℓ of said upper high surface area electrode when

13 wetted with an element of interest for which a fluidic

14 concentration is to be measured by said cell, in a fluid to be

15 flowed through said cell.

1 166. (new) The optimization method of claim 165, wherein:

2   said $\ell = 1/(\mu * \rho)$;

3   μ designates a mass absorption coefficient of said upper

4 high surface area electrode when wetted with said element of

5 interest in said fluid; and

6   ρ designates a material density of said upper high surface

7 area electrode when wetted with said element of interest in said

8 fluid.

1 167. (new) The optimization method of claim 165, further

2 comprising the step of:

3   optimizing said lower high surface area electrode with a

4 lower electrode thickness less than or equal to approximately an

5 optical depth ℓ of said lower high surface area electrode when

6 wetted with said element of interest, in said fluid.

1 168. (new) The optimization method of claim 167, wherein:

2   said $\ell = 1/(\mu * \rho)$;

3   μ designates a mass absorption coefficient of said lower

4 high surface area electrode when wetted with said element of

5 interest in said fluid; and

6   ρ designates a material density of said lower high surface

7 area electrode when wetted with said element of interest in said

62

8   fluid.

1   169.   (new) An optimized ionic preconcentration cell product,

2   optimized for identifying and measuring concentrations of

3   elements in fluids; said ionic preconcentration cell comprising

4   an upper high surface area electrode comprising a high specific

5   surface area thereof; a lower high surface area electrode

6   comprising a high specific surface area thereof; and a central

7   flow interelectrode gap separating said upper and lower high

8   surface area electrodes by a predetermined interelectrode gap

9   width; produced by a process comprising the step of:

10   optimizing said upper high surface area electrode with an

11   upper electrode thickness less than or equal to approximately an

12   optical depth ℓ of said upper high surface area electrode when

13   wetted with a fluid to be flowed through said cell.

1   170. (new) The optimized product-by-process of claim 169,

2   wherein:

3   said $\ell = 1/(\mu^*\rho)$;

4   μ designates a mass absorption coefficient of said upper

5   high surface area electrode when wetted with said fluid; and

6   ρ designates a material density of said upper high surface

7   area electrode when wetted with said fluid.

1   171.   (new) The optimized product-by-process of claim 169,

2   further comprising the step of:

3   optimizing said lower high surface area electrode with a

4   lower electrode thickness less than or equal to approximately an

5   optical depth ℓ of said lower high surface area electrode when

63

6   wetted with said fluid.

1   172.   (new)   The optimized product-by-process of claim 171,

2   wherein:

3   said $\ell = 1/(\mu * \rho)$;

4   μ designates a mass absorption coefficient of said lower

5   high surface area electrode when wetted with said fluid; and

6   ρ designates a material density of said lower high surface

7   area electrode when wetted with said fluid.

1   173.   (new)   An optimized ionic preconcentration cell product,

2   optimized for identifying and measuring concentrations of

3   elements in fluids; said ionic preconcentration cell comprising

4   an upper high surface area electrode comprising a high specific

5   surface area thereof; a lower high surface area electrode

6   comprising a high specific surface area thereof; and a central

7   flow interelectrode gap separating said upper and lower high

8   surface area electrodes by a predetermined interelectrode gap

9   width; produced by a process comprising the step of:

10   optimizing said upper high surface area electrode with an

11 upper electrode thickness less than or equal to approximately an

12 optical depth ℓ of said upper high surface area electrode when

13 wetted with an element of interest for which a fluidic

14 concentration is to be measured by said cell, in a fluid to be

15 flowed through said cell.

1   174.   (new)   The optimized product-by-process of claim 173,

2   wherein:

3   said $\ell = 1/(\mu * \rho)$;

64

4   μ designates a mass absorption coefficient of said upper

5   high surface area electrode when wetted with said element of

6   interest in said fluid; and

7   ρ designates a material density of said upper high surface

8   area electrode when wetted with said element of interest in said

9   fluid.

1   175.   (new) The optimized product-by-process of claim 173,

2   further comprising the step of:

3   optimizing said lower high surface area electrode with a

4   lower electrode thickness less than or equal to approximately an

5   optical depth ℓ of said lower high surface area electrode when

6   wetted with said element of interest, in said fluid.

1   176.   (new) The optimized product-by-process of claim 175,

2   wherein:

3   said $\ell = 1/(\mu * \rho)$;

4   μ designates a mass absorption coefficient of said lower

5   high surface area electrode when wetted with said element of

6   interest in said fluid; and

7   ρ designates a material density of said lower high surface

8   area electrode when wetted with said element of interest in said

9   fluid.

1   177.   (new) A method of optimizing fabrication of an ionic

2   preconcentration cell for identifying and measuring

3   concentrations of elements in fluids; said ionic preconcentration

4   cell comprising an upper high surface area electrode comprising a

5   high specific surface area thereof; a lower high surface area

65

6 electrode comprising a high specific surface area thereof; and a

7 central flow interelectrode gap separating said upper and lower

8 high surface area electrodes by a predetermined interelectrode

9 gap width; said method comprising the step of:

10   optimizing said central flow interelectrode gap comprising

11 said predetermined interelectrode gap width, designated d, within

12 an interelectrode gap range specified by:

13
$$d = \frac{\sigma}{q} \frac{\Phi}{\varepsilon} \frac{w_i}{w_f} \frac{A}{n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \varepsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\varepsilon F}; \text{ wherein:}$$

14   ε designates a predetermined percentage of at least one

15 element of interest to be extracted from a fluid to be flowed

16 through said cell, σ designates a composite conductivity of said

17 fluid, Φ designates said voltage differential applied across

18 said electrodes, $q = 1.60 \times 10^{-19}$ Coulomb designates the unit

19 charge, A designates an ordinary surface area covered by said

20 electrodes, n_f designates a number density of said fluid, w_i and

21 w_f designate atomic / molecular weights, respectively, of said at

22 least one element of interest and of said fluid, C designates a

23 concentration of said at least one element of interest in said

24 fluid, and F designates a flow rate of said fluid through said

25 ionic preconcentration cell;

26   said high surface area electrodes further comprise said

27 ordinary surface area A approximately equal to an interrogation

28 spot area of x-rays to which said preconcentration cell is to be

29 exposed;

30   said ε is chosen to be below approximately 5% for said at

31 least one element of interest;

66

32 said Φ is chosen to be below an electrochemical potential of

33 said at least one element of interest and below an electrolysis

34 potential of said fluid;

35 said F is chosen to exert no more than approximately .1 atm

36 of pressure upon an upper x-ray transmission window of said ionic

37 preconcentration cell in intimate contact with an upper surface

38 of said upper high surface area electrode;

39 said n_f and said w_f are chosen with reference to said at

40 least one element of interest; and

41 said w_i is chosen with reference to said fluid.

1 178. (new) The optimization method of claim 177, wherein:

2 as a consequence of said optimizing, said central flow

3 interelectrode gap comprises said predetermined interelectrode

4 gap width, d, with:

5 a minimum gap width selected from a minimum gap width group

6 consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

7 a maximum gap width selected from a maximum gap width group

8 consisting of 2 mm, 5 mm, and 10 mm.

1 179. (new) An optimized ionic preconcentration cell product,

2 optimized for identifying and measuring concentrations of

3 elements in fluids; said ionic preconcentration cell comprising

4 an upper high surface area electrode comprising a high specific

5 surface area thereof; a lower high surface area electrode

6 comprising a high specific surface area thereof; and a central

7 flow interelectrode gap separating said upper and lower high

8 surface area electrodes by a predetermined interelectrode gap

9 width; produced by a process comprising the step of:

10   optimizing said central flow interelectrode gap comprising

11   said predetermined interelectrode gap width, designated d, within

12   an interelectrode gap range specified by:

13     $$d = \frac{\sigma}{q}\frac{\Phi}{\varepsilon}\frac{w_i}{w_f}\frac{A}{n_f\,C\,F} \times 100\% \approx 2\times10^{-9}\,\frac{\Phi w_i A}{q\varepsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\varepsilon F}\,;\ \text{wherein:}$$

14   ε designates a predetermined percentage of at least one

15   element of interest to be extracted from a fluid to be flowed

16   through said cell, σ designates a composite conductivity of said

17   fluid, Φ designates said voltage differential applied across

18   said electrodes, $q = 1.60\times10^{-19}$ Coulomb designates the unit

19   charge, A designates an ordinary surface area covered by said

20   electrodes, n_f designates a number density of said fluid, w_i and

21   w_f designate atomic / molecular weights, respectively, of said at

22   least one element of interest and of said fluid, C designates a

23   concentration of said at least one element of interest in said

24   fluid, and F designates a flow rate of said fluid through said

25   ionic preconcentration cell;

26   said high surface area electrodes further comprise said

27   ordinary surface area A approximately equal to an interrogation

28   spot area of x-rays to which said preconcentration cell is to be

29   exposed;

30   said ε is chosen to be below approximately 5% for said at

31   least one element of interest;

32   said Φ is chosen to be below an electrochemical potential of

33   said at least one element of interest and below an electrolysis

34   potential of said fluid;

68

35   said F is chosen to exert no more than approximately .1 atm

36   of pressure upon an upper x-ray transmission window of said ionic

37   preconcentration cell in intimate contact with an upper surface

38   of said upper high surface area electrode;

39   said n_f and said w_f are chosen with reference to said at

40   least one element of interest; and

41   said w_i is chosen with reference to said fluid.

1   180. (new) The optimized product-by-process of claim 179,

2   wherein:

3   as a consequence of said optimizing, said central flow

4   interelectrode gap comprises said predetermined interelectrode

5   gap width, d, with:

6   a minimum gap width selected from a minimum gap width group

7   consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

8   a maximum gap width selected from a maximum gap width group

9   consisting of 2 mm, 5 mm, and 10 mm.

1   181.   (new) An ionic preconcentration cell apparatus for

2   identifying and measuring concentrations of elements in fluids,

3   comprising:

4   an upper high surface area electrode comprising a high

5   specific surface area thereof;

6   a lower high surface area electrode comprising a high

7   specific surface area thereof, substantially parallel to said

8   upper high surface area electrode;

9   a central flow interelectrode gap separating said upper and

10   lower high surface area electrodes by a predetermined

11   interelectrode gap width;

69

12   fluid flow means for flowing a fluid through said central

13 flow interelectrode gap; and

14   said upper high surface area electrode and said lower high

15 surface area electrode each comprising a high surface area

16 material in turn comprising an x-ray transparency greater than

17 approximately 90% for characteristic photon energies from an

18 element of interest for which a fluidic concentration is to be

19 measured.

1   182.   (new) The apparatus of 181, said high surface area

2   material further comprising:

3   a large plurality of pores characterized by a specific

4   surface area of at least approximately 100 m^2/g;

5   an average pore diameter of said pores between approximately

6   30 nm and 10 nm per pore.

1   183.   (new) The apparatus of 181, said high surface area

2   material further comprising:

3   the ability to contain approximately at least 0.1% by weight

4   of foreign material relative to said high surface area material

5   prior to saturation.

1   184.   (new) The apparatus of 181, said high surface area

2   material further comprising:

3   high structural rigidity wherein a displacement under the

4   flow of said fluid does not exceed approximately 0.25mm.

1   185.   (new) The apparatus of 181, said high surface area

2   material further comprising:

3   freedom from metallic impurities in excess of approximately

4   .5 parts per million, when measured by x-ray fluorescence

70

5   analysis.

1   186.   (new)   A method for identifying and measuring

2   concentrations of elements in fluids, comprising the steps of:

3   flowing a fluid through a central flow interelectrode gap of

4   an ionic preconcentration cell separating an upper high specific

5   surface area electrode from a lower high specific surface area

6   electrode of said ionic preconcentration cell by a predetermined

7   interelectrode gap width;

8   applying a voltage differential between said upper high

9   surface area electrode and said lower high surface area electrode

10 while said fluid is flowing through said central flow

11 interelectrode gap;

12   exposing said cell to x-rays;

13   deducing an identity, or measurement of concentration, of at

14 least one element in said fluid based on a response of said

15 preconcentration cell to said x-rays; and

16   providing said upper high surface area electrode and said

17 lower high surface area electrode each comprising a high surface

18 area material in turn comprising an x-ray transparency greater

19 than approximately 90% for characteristic photon energies from an

20 element of interest for which a fluidic concentration is to be

21 measured.

1   187.   (new)   The method of claim 186, further comprising the

2   step of providing said high surface area material further

3   comprising:

4   a large plurality of pores characterized by a specific

5   surface area of at least approximately 100 m^2/g;

71

6   an average pore diameter of said pores between approximately

7   30 nm and 10 nm per pore.

1   188.   (new)   The method of claim 186, further comprising the

2   step of providing said high surface area material further

3   comprising:

4   the ability to contain approximately at least 0.1% by weight

5   of foreign material relative to said high surface area material

6   prior to saturation.

1   189.   (new)   The method of claim 186, further comprising the

2   step of providing said high surface area material further

3   comprising:

4   high structural rigidity wherein a displacement under the

5   flow of said fluid does not exceed approximately 0.25mm.

1   190.   (new)   The method of claim 186, further comprising the

2   step of providing said high surface area material further

3   comprising:

4   freedom from metallic impurities in excess of approximately

5   .5 parts per million, when measured by x-ray fluorescence

6   analysis.

1   191.   (new)   An ionic preconcentration cell apparatus for

2   identifying and measuring concentrations of elements in fluids,

3   comprising:

4   an upper high surface area electrode comprising a high

5   specific surface area thereof;

6   a lower high surface area electrode comprising a high

7   specific surface area thereof, substantially parallel to said

8   upper high surface area electrode;

72

9   a central flow interelectrode gap separating said upper and

10   lower high surface area electrodes by a predetermined

11   interelectrode gap width;

12   fluid flow means for flowing a fluid through said central

13   flow interelectrode gap; and

14   flow control means for controlling a flow rate of said fluid

15   through said ionic preconcentration cell so as to maintain ε,

16   which designates a predetermined percentage of at least one

17   element of interest to be extracted from said fluid, below

18   approximately 5% for said at least one element of interest.

1   192.   (new)   The apparatus of claim 191, wherein said ε is

2   maintained below an extraction percentage selected from an

3   extraction percentage group consisting of approximately 4%, 3%,

4   2%, and 1%.

1   193.   (new)   The apparatus of claim 191, further comprising:

2   voltage application means for applying a voltage

3   differential between said upper high surface area electrode and

4   said lower high surface area electrode while said fluid is

5   flowing through said central flow interelectrode gap; and

6   said flow control means for controlling said flow rate F of

7   said fluid through said ionic preconcentration cell and

8   maintaining said F at a substantially constant level so as to

9   maintain said ε, which is specified by:

10    $$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma\,\Phi}{qd}\frac{w_i}{w_f}\frac{A}{n_f\,CF}\times100\%\,,$$

11   below approximately 5% for said at least one element of interest;

12   wherein:

73

13   Γ_{ie} and Γ_{is} designate rates at which ions of said at least

14   one element of interest are respectively extracted from said

15   fluid by said cell and supplied to said cell by said fluid, σ

16   designates a composite conductivity of said fluid, Φ designates

17   a potential applied by said voltage application means across said

18   electrodes, d designates said predetermined interelectrode gap

19   width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$

20   Coulomb designates the unit charge, A designates an ordinary

21   surface area covered by said electrodes, n_f designates a number

22   density of said fluid, w_i and w_f designate atomic / molecular

23   weights, respectively, of said at least one element of interest

24   and of said fluid, and C designates a concentration of said at

25   least one element of interest in said fluid; and

26   for having said concentration C in a range where

27   conductivity varies substantially linearly with concentration,

28   with C in units of parts per billion, wherein σ is approximated

29   by:

30    $\sigma \approx 2 \times 10^{-9} \, C / \mathrm{Ohm} - \mathrm{cm}$.

1   194.   (new) The apparatus of claim 193, wherein said ε is

2   maintained below an extraction percentage selected from the

3   extraction percentage group consisting of approximately 4%, 3%,

4   2% and 1%.

1   195.   (new) A method for identifying and measuring

2   concentrations of elements in fluids, comprising the steps of:

3   flowing a fluid through a central flow interelectrode gap of

4   an ionic preconcentration cell separating an upper high specific

74

5   surface area electrode from a lower high specific surface area

6   electrode of said ionic preconcentration cell by a predetermined

7   interelectrode gap width;

8   applying a voltage differential between said upper high

9   surface area electrode and said lower high surface area electrode

10 while said fluid is flowing through said central flow

11 interelectrode gap;

12   exposing said cell to x-rays;

13 ·   deducing an identity, or measurement of concentration, of at

14 least one element in said fluid based on a response of said

15 preconcentration cell to said x-rays; and

16   controlling a flow rate of said fluid through said ionic

17 preconcentration cell so as to maintain ε, which designates a

18 predetermined percentage of at least one element of interest to

19 be extracted from said fluid, below approximately 5% for said at

20 least one element of interest.

1   196.   (new) The method of claim 195, further comprising the

2   step of:

3   maintaining said ε below an extraction percentage selected

4   from an extraction percentage group consisting of approximately

5   4%, 3%, 2%, and 1%.

1   197.   (new) The method of claim 195, said step of controlling

2   said flow rate further comprising the step of:

3   controlling said flow rate F of said fluid through said

4   ionic preconcentration cell and maintaining said F at a

5   substantially constant level so as to maintain said ε, which is

6   specified by:

75

7 $$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi}{q d} \frac{w_i}{w_f} \frac{A}{n_f C F} \times 100\% ,$$

8   below approximately 5% for said at least one element of interest;

9   wherein:

10   Γ_{ie} and Γ_{is} designate rates at which ions of said at least

11   one element of interest are respectively extracted from said

12   fluid by said cell and supplied to said cell by said fluid, σ

13   designates a composite conductivity of said fluid, Φ designates

14   said voltage differential applied across said electrodes, d

15   designates said predetermined interelectrode gap width of said

16   central flow interelectrode gap, $q = 1.60 \times 10^{-19}$ Coulomb designates

17   the unit charge, A designates an ordinary surface area covered by

18   said electrodes, n_f designates a number density of said fluid,

19   w_i and w_f designate atomic / molecular weights, respectively, of

20   said at least one element of interest and of said fluid, and C

21   designates a concentration of said at least one element of

22   interest in said fluid; and

23   having said concentration C in a range where conductivity

24   varies substantially linearly with concentration, with C in units

25   of parts per billion, wherein σ is approximated by:

26      $$\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm} .$$

1   198.   (new)   The method of claim 197, further comprising the

2   step of:

3   maintaining said ε below an extraction percentage selected

4   from an extraction percentage group consisting of approximately

5   4%, 3%, 2%, and 1%.

76

1   199.   (new)   An ionic preconcentration cell apparatus for

2   identifying and measuring concentrations of elements in fluids,

3   comprising:

4   an upper high surface area electrode comprising a high

5   specific surface area thereof;

6   a lower high surface area electrode comprising a high

7   specific surface area thereof, substantially parallel to said

8   upper high surface area electrode;

9   a central flow interelectrode gap separating said upper and

10 lower high surface area electrodes by a predetermined

11 interelectrode gap width;

12   fluid flow means for flowing a fluid through said central

13 flow interelectrode gap; and

14   time control means for controlling how long said fluid flows

15 through said ionic preconcentration cell based on setting an

16 impurity concentration C, in a range where conductivity varies

17 substantially linearly with concentration, to a predetermined

18 desired concentration detection level and flowing said fluid for

19 a time t given by:

20         $$t \propto \frac{S\ell}{\sigma} \propto \frac{S\ell}{C} \; ; \text{ wherein:}$$

21   S designates a sensitivity of x-ray detection equipment to

22 be used for said detecting and measuring;

23   ℓ designates a thickness of said upper high surface area

24 electrode; and

25   σ designates a composite conductivity of said fluid.

77

1   200.   (new) A method for identifying and measuring

2   concentrations of elements in fluids, comprising the steps of:

3   flowing a fluid through a central flow interelectrode gap of

4   an ionic preconcentration cell separating an upper high specific

5   surface area electrode from a lower high specific surface area

6   electrode of said ionic preconcentration cell by a predetermined

7   interelectrode gap width;

8   applying a voltage differential between said upper high

9   surface area electrode and said lower high surface area electrode

10   while said fluid is flowing through said central flow

11   interelectrode gap;

12   exposing said cell to x-rays;

13   deducing an identity, or measurement of concentration, of at

14   least one element in said fluid based on a response of said

15   preconcentration cell to said x-rays;

16   setting an impurity concentration C, in a range where

17   conductivity varies substantially linearly with concentration, to

18   a predetermined desired concentration detection level; and

19   controlling how long said fluid flows through said ionic

20   preconcentration cell by flowing said fluid for a time t given

21   by:

22        $t \propto \dfrac{S\ell}{\sigma} \propto \dfrac{S\ell}{C}$, wherein:

23   S designates a sensitivity of x-ray detection equipment to

24   be used for said detecting and measuring;

25   ℓ designates a thickness of said upper high surface area

26   electrode; and

78

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27   σ designates a composite conductivity of said fluid.

79